ENVIRONMENTAL MONITORING OF FORESTRY CONTROL OPERATIONS (EMOFCO)

1987 REPORT

COMPILED BY:

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MUNICIPAL AFFAIRS AND ENVIRONMENT

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1988

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ERRATA

p. 44, line 10 should read

moss (8-10 ug/g), and sediment (<0.01 ug/g).

ABSTRACT

This multi-disciplinary compilation of 18 reports concerns primarily the environmental monitoring of the spruce budworm and the forest herbicide aerial spray operations in New Brunswick in 1987. The 33 authors report on the operational, research and regulatory aspects of both spray programs. (Although some of the herbicide reports relate primarily to efficacy, they were included in order to introduce research products that have potential for use in forest management.) The pesticides investigated are:

- insecticides - aminocarb, fenitrothion, and Bacillus thuringiensis (various formulations); and
- herbicides - glyphosate, hexazinone, sulfometuron-methyl, and metsulfuron-methyl.

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FOREWORD

The New Brunswick Committee for Environmental Monitoring of Forestry Control Operations (EMOFCO), formerly the New Brunswick Committee for Environmental Monitoring of Forest Insect Control Operations (EMOFICO), is an informal association of biologists, foresters, environmental specialists and chemists from federal and provincial governments, industry and universities. Its prime objective is to exchange information on the impact of operational spray programs, now including both herbicide and insecticide spray programs, on non-target organisms and ecological processes in forest and adjacent ecosystems. By implication this includes experimental sprays and complementary laboratory studies. Efficacy is also considered, insofar as it relates to environmental effects. The potential consequences of forest spray programs for human health are beyond the Committee's terms of reference. Although the Committee's focus is on spray activities in New Brunswick, it seeks to keep aware of forestry control operations and related environmental studies in the Atlantic region as well as in Quebec and Maine.

The Committee assumed its name and structure in 1976, and has been under the aegis of the Department of Municipal Affairs and Environment (formerly the Department of the Environment) since 1980. The Committee was modified in 1987 to incorporate forest herbicides into the terms of reference as a result of the increased interest in the use of these products as forest management tools. The 1987 report, like its predecessors, is aimed at a broad readership - scientists, regulators, resource managers and the public. It consists essentially of preliminary reports and abstracts of reports completed.

Steering Committee

D. C. Eidt (Canadian Forestry Service)
W. R. Ernst (Environment Canada)
W. A. Sexsmith, Secretary (N.B. Department of Municipal Affairs and Environment
D. R. Silliphant, Chairman (N.B. Department of Municipal Affairs and Environment

RECOMMENDATIONS

A consensus of the EMOFCO Committee:

It is recommended

(1) that inasmuch as the operational use of fenitrothion at conventional dosages may sometimes effect birds, pollinating insects, and aquatic invertebrates, more environmentally acceptable alternatives to present use patterns of fenitrothion must continue to be actively sought;

(2) that there be intensified effort into basic research on forestry insecticides which are environmentally acceptable;

(3) that inasmuch as biological impacts that have been measured after forestry insecticide spray programs may be associated with highly variable insecticide deposits, there be more effort made to determine the cause of this variability and identify ways in which it may be reduced;

(4) that inasmuch as plant pollination systems, which are dependent upon insects, may be critical ecological processes, forest spraying effects on such systems needs to be further studied;

(5) that inasmuch as possible impacts of B.t. on non-target insects (Lepidoptera) may indirectly affect interspecific competition among plants and habitat, or food supply for some fauna, information on environmental effects of B.t. be reviewed, research gaps be identified, and priorities be established;

(6) that regulatory agencies continue to review the rationale for the specifications for environmental buffer zones, in keeping with information provided by spray technology research;

(7) that inasmuch as EMOFCO is now concerned with the environmental effects of forestry herbicides, efforts be made to review the present forestry herbicide environmental effects data base and identify research priorities for data gaps.

INSECTICIDES

OPERATIONAL SPRAYING

1987 NEW BRUNSWICK PROTECTION PROGRAM AGAINST SPRUCE BUDWORM

N. Carter

1987 Spray Program

The 1987 Spruce Budworm Spray Program (Figure 1) conducted by Forest Protection Limited (FPL), covered approximately 478 300 hectares. This is slightly less than the 496 000 ha treated in 1986. Of the total area treated, about 90 percent was in the industrial part of the program (i.e. beyond 1.6 km from habitation) and the balance was in the non-industrial sector consisting primarily of small private woodlots.

Of the total area treated by FPL, 75% received a double application of fenitrothion (Sumithion) and 5.9% received one application of aminocarb (Matacil 180F) followed by one application of fenitrothion. About 17% of the area received a single treatment of bacterial insecticide, Bacillus thuringiensis var. kurstaki (B.t.). The remaining 2% of the area received a single application of fenitrothion followed by a single application of B.t. (Table 1).

Spray aircraft included TBMs and single-engine agricultural-type small spray planes (SSPs). TBMs were used to treat 85% of the total treatment area. This year's program was characterized by the operational use of rotary atomizers (Micronair AU4000) on some of the TBMs and the application of lower volume and lower dosage rates of insecticides.

The first spray blocks were biologically ready for spraying with chemicals on May 22nd and spray operations commenced on that morning. This commencement date was four days earlier than the past three years. Other blocks were declared biologically ready on subsequent days. The first areas slated for B.t. treatment were declared ready for spraying on May 24th. Spraying with B.t. was delayed, however, due to the discovery of another bacteria called Streptococcus in the spray material. The use of B.t. was delayed until a definite clearance was received from both provincial and federal health and environment authorities. This approval was received on May 28th and the first B.t. was applied on the morning of May 29th. Also, on May 28th all blocks, both B.t. and chemical, were declared biologically ready for treatment. The project was completed on the evening of June 18th.

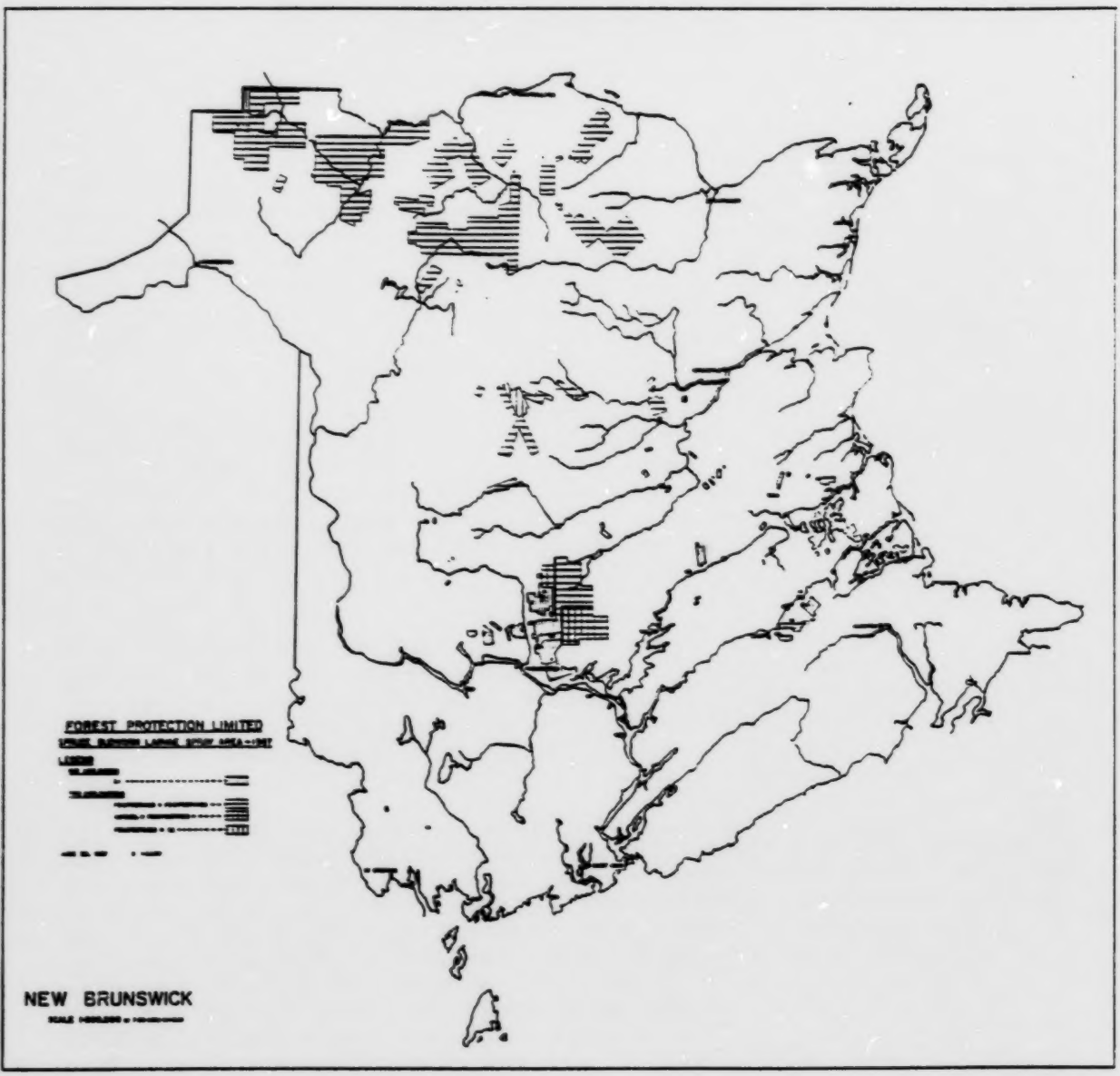

Figure 1. Areas sprayed by FPL for spruce budworm control in New Brunswick in 1987. (Does not include J.D. Irving program).

The development of both insects and tree foliage in 1987 was different from the expected progression of development from south to north, from low ground to high ground; and delays due to proximity of the cold Northumberland Strait did not occur. Northern and southeastern coastal areas developed almost as rapidly as those in the central Grand Lake region.

Excellent spray weather occurred from May 22nd until May 27th, during which period only limited areas were ready for spraying. From then on only marginally acceptable weather for short periods occurred through to the end of the project. In fact, due to the marginal weather and the uniform and rapid development of the insect, most of the second application of chemical was delayed beyond the optimum five-day interval after first application. Also, due to questions surrounding approval of B.t. and the weather, much of the B.t. application was delayed five days and more beyond the optimum treatment date.

Results of Spray Program

Objectives of the program were to limit budworm defoliation and retain 60% or more of the current year's needles on balsam fir (Abies balsamea (L.) Mill.) and 50% or more on red-black spruce (Picea rubens Sarg.-P. mariana (Mill.) B.S.P.). Differences between expected levels of defoliation of balsam fir were detected between the north and south with more severe feeding occurring in the north (Table 2). In the north only 34% of sampled trees from untreated check areas had defoliation less than 40% compared to 87% in the check samples in the south. In the north sampled fir trees from untreated check areas had mean defoliation of 62% compared to 34% and 25% from TBM and SSP treatments respectively. In the south, sampled fir trees from untreated check plots had mean defoliation of 21% compared to 12% and 8% from TBM and SSP treatments respectively. Results on red-black spruce were less demonstrable because mean defoliation on check trees in the southern region was only 18%. A subset of the data revealed that average defoliation levels on both species in treatment blocks was greatly reduced below that observed in check areas when based on equal pre-spray populations.

Based on the aerial defoliation survey there were about 75 121 ha of moderate and severe defoliation detected within all spray areas. This represented 17.5% of the total Province-wide moderate and severe defoliation, or 15.7% of the total area treated by all insecticides.

Table 1. Areas sprayed by Forest Protection Limited for spruce budworm control in 1987 in New Brunswick*. (Does not include J.D. Irving program).

Treatment	Hectares Thousands	(%)	Acres Thousands	Aircraft Type
One Application				
15 B.I.U./ha B.t. (Dipel)	2.4	(0.5)	6.1	Ag truck
30 B.I.U./ha B.t. (Dipel or Futura)	79.3	(16.6)	195.9	Ag cat, Ag truck TBM
Sub-Total	81.7	(17.1)	202.0	
Two Applications				
(a) 210 g/ha Fenitrothion+ 210 g/ha Fenitrothion	265.7	(55.5)	656.6	TBM Ag truck
(b) 140 g/ha Fenitrothion+ 140 g/ha Fenitrothion	41.8	(8.7)	103.4	TBM
(c) 210 g/ha Fenitrothion+ 140 g/ha Fenitrothion	20.5	(4.3)	50.6	TBM
(d) 140 g/ha Fenitrothion+ 210 g/ha Fenitrothion	30.7	(6.4)	75.9	TBM
(e) 70 g/ha Matacil+ 210 g/ha Fenitrothion	28.3	(5.9)	69.9	TBM
(f) 210 g/ha Fenitrothion+ 30 B.I.U./ha B.t.	9.6	(2.0)	23.6	TBM
Sub-Total	396.6	(82.9)	980.0	
Grand Total	478.3	(100.0)	1182.0	

*Source: Forest Protection Ltd.

Spruce Budworm Conditions in 1987

The 1987 aerial defoliation survey was conducted in the standard manner and revealed an estimated 88 000 ha of light, 189 000 ha of moderate, and 241 000 ha of severe defoliation (Figure 2). Approximately 82.5% of the M-S defoliation was outside the treated areas. Defoliation was again scattered around the Province similar to 1986, with largest concentrations found throughout the north-central, northwest and in the central areas. The western border, most of the south, and northeastern parts of the Province were undamaged. The 430 000 ha of M-S defoliation represent a 54% decrease from 1986, and a significant 79% decrease from the 2.03 million ha in 1983.

Forecast of Infestation for 1988

The spruce budworm egg mass survey was replaced by the L2 survey in 1985 as the method of forecasting infestation levels in New Brunswick. Supplementary L2 sampling is also conducted throughout the winter months to assist in planning the protection program. Table 3 compares the proportion of sample points within each infestation category used in the forecasts from 1981 to 1987. This table indicates an increasing trend in the percent of points in the Low category with a corresponding decreasing trend for the High category since 1982. In 1987, however, there was a three-fold increase in the proportion of points in the High category. This intensification occurs in the North-central to North-western parts of the Province where virtually all of these high points were found.

In light of these changes in population intensity, the forecast for 1988 is for 1.505 million ha (Figure 3) of moderate to high infestation. This total also includes four areas of variable populations where all categories of infestation are common and hence scattered patches of defoliation are expected. Isolated pockets of moderate to high populations were also detected but no area designation was practical, and hence not included in the forecast area figure. The forecast is a 12% reduction from last year's forecast. Most severe damage is expected in the northern part of the Province, whereas no significant damage is expected in the southern third of the Province or throughout most of the western, eastern and northeastern areas.

Plans for 1988

Spray plans for 1988 have not been formulated at this time. Nevertheless, it does appear that a protection program will be required in New Brunswick next year. We anticipate that a combination of chemical insecticides and B.t. will again be used though the relative amounts are not known. Tentative spray plans should be known by mid-December.

Table 2. Number of balsam fir and red-black spruce trees sampled mean % defoliation and percent meeting foliage protection objectives in Northern and Southern New Brunswick.

Treatment*	Number	Mean	(%)		Number	Mean	(%)
NORTHERN		balsam fir				balsam fir	
TBM				SSP			
F210b + F210b	815	33	(65)	F210 + F210	309	12	(94)
F210m + F210m	238	55	(41)	A70 + A70 (JDI)	87	25	(84)
F140m + F140m	339	43	(53)	F210 + F210 (JDI)	56	60	(27)
F210m + F210b	158	8	(99)	F210 + A70 (JDI)	75	56	(41)
F210b + F140m	39	22	(77)		527	25	(77)
F140m + F210b	156	15	(90)				
F210b + B.t.	81	28	(73)	CHECKS	270	62	(34)
	1826	34	(65)				
SOUTHERN							
TBM		balsam fir				red-black spruce	
F210b + F210b	-	-	-		78	4	(100)
A70 + F210b	131	11	(90)		203	7	(100)
1 X B.t.	20	1	(100)		78	5	(100)
TBM/SSP							
F210 + F210b	78	14	(95)		-	-	-
	229	12	(92)		359	6	(100)
SSP							
1 X B.t.	682	7	(96)		1133	7	(100)
A70 + A70 (JDI)	125	13	(87)		75	8	(100)
	807	8	(95)		1208	7	(100)
CHECKS	176	21	(87)		274	18	(93)

* F = fenitrothion; A = aminocarb (= Matacil), M = Micronair AU4000 b = boom and nozzle; JDI = J. D. Irving Ltd.

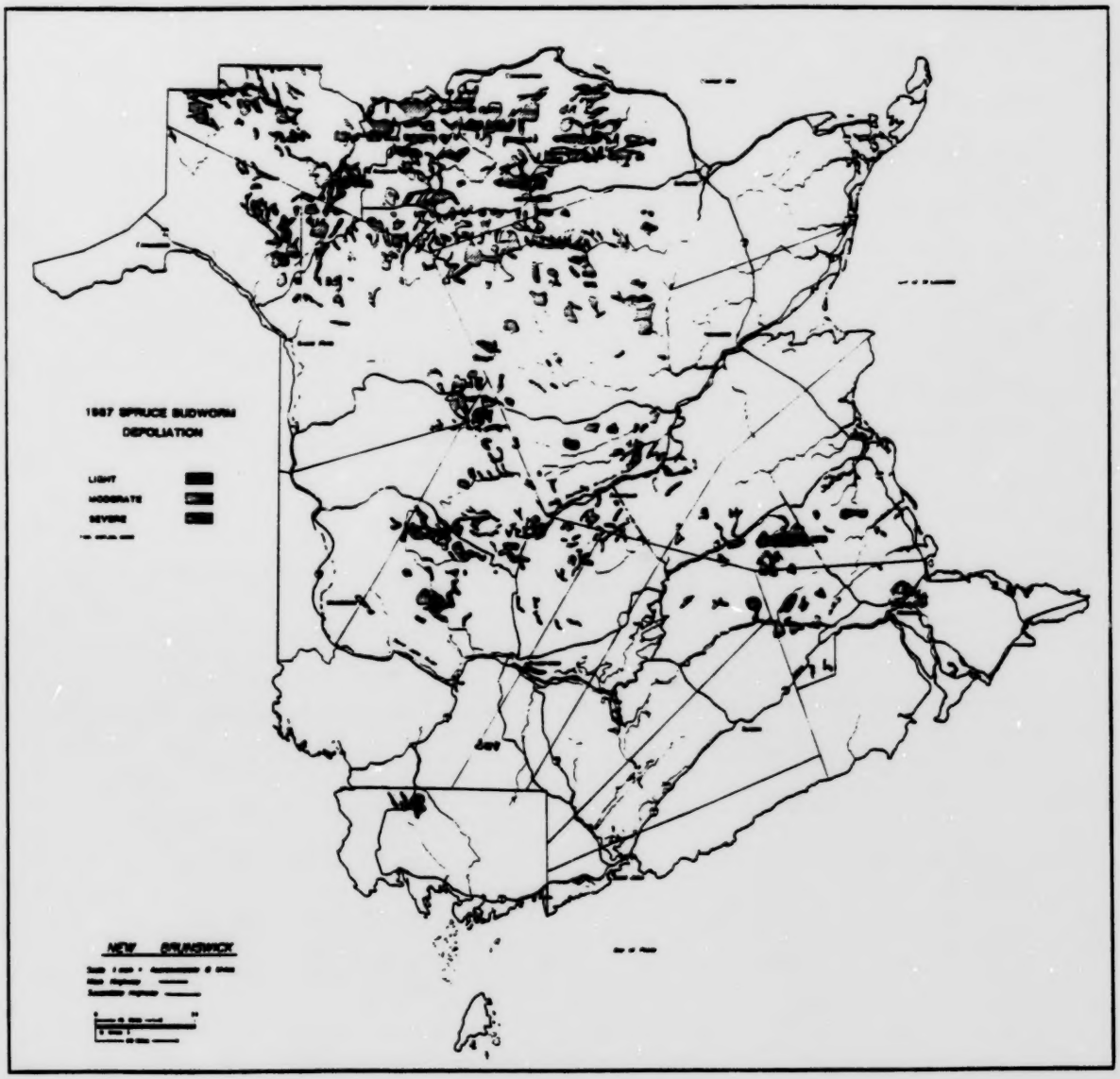

Figure 2. Area of light, moderate and severe defoliation based on 1987 aerial defoliation survey.

Table 3. Comparison of Spruce Budworm Forecast Infestation Levels 1981-1987.

YEAR	FORECAST INFESTATION LEVEL			
	LOW	MODERATE	HIGH	LOCATIONS
1981 egg-mass	591 (34%)	441 (25%)	708 (41%)	1740
1982 egg-mass	458 (26%)	512 (29%)	783 (45%)	1753
1983 egg-mass	636 (48%)	257 (20%)	423 (32%)	1316
1984 egg-mass \L2	747 (51%)	331 (22%)	398 (27%)	1476
1985 L2	833 (56%)	503 (32%)	185 (12%)	1521
1986 L2	1216 (77%)	322 (20%)	48 (3%)	1586
1987 L2	1198 (76%)	230 (15%)	144 (9%)	1572

Table 4. Comparison of Forecast Area (ha) of Moderate and High Infestations 1982-1987.

YEAR (N)	(N + 1) FORECAST
1982	5.30 million ha
1983	4.10 million ha
1984	3.57 million ha
1985	3.15 million ha
1986	1.71 million ha
1987	1.50 million ha

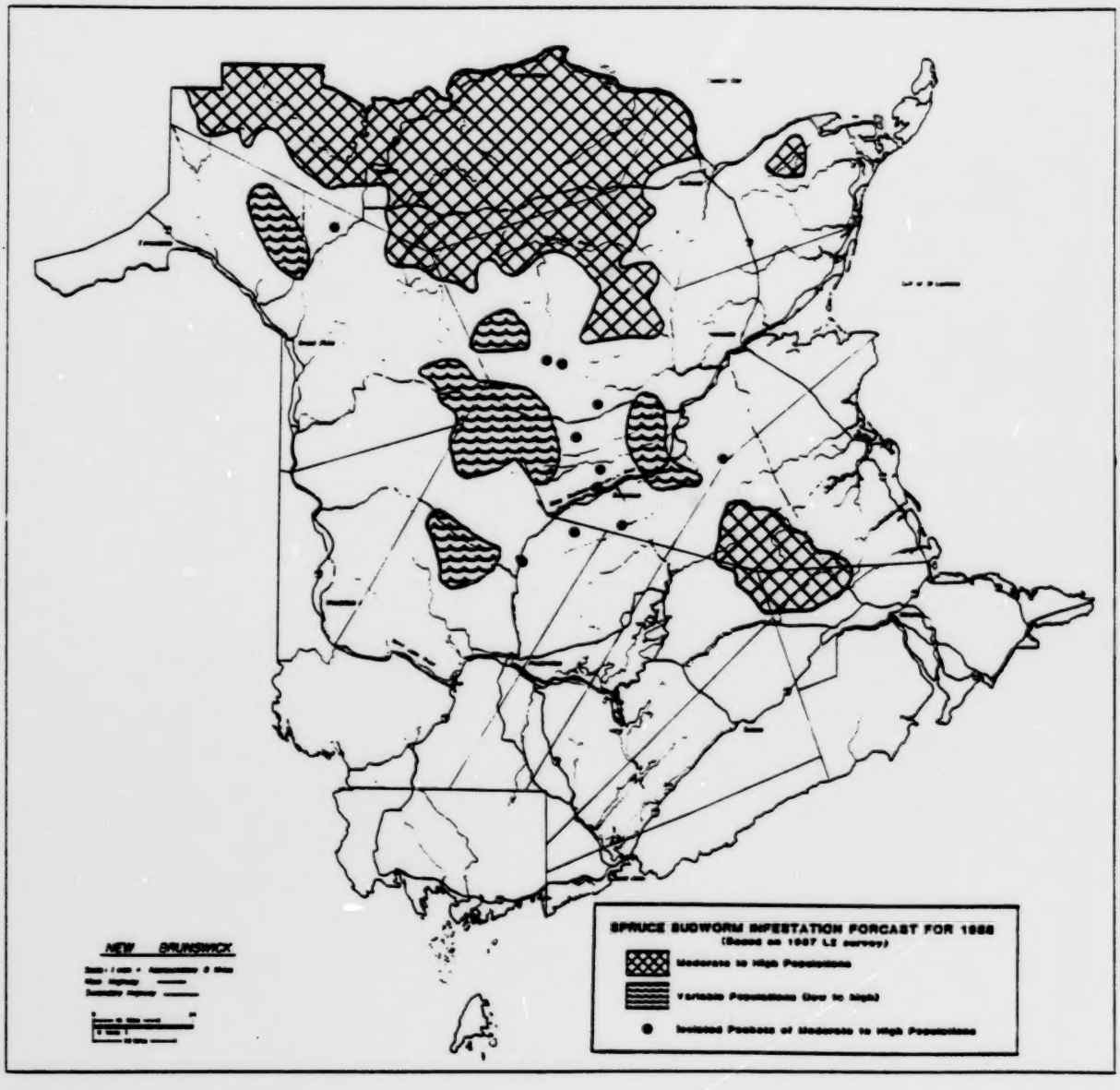

Figure 3. Areas forecast to have moderate and high infestation levels in 1988 based on the 1987 L2 survey.

EXPERIMENTAL SPRAYING

REVIEW OF RESEARCH AND DEVELOPMENT PROGRAMS CONDUCTED IN NEW BRUNSWICK IN 1987 TO EVALUATE PESTICIDES AND TACTICS AGAINST THE SPRUCE BUDWORM (C. fumifeirana) AND THE SPRUCE BUDMOTH (Z. canadensis)

E. G. KETTELA

Research and Development Efforts in Pest Control

The following is a brief review of pest control efforts in which I have been involved in the past year. This covers work carried out in cooperation with Forest Protection Ltd., NB SERG, and J. D. Irving Ltd. The primary thrust of these investigations has been in the validation of the UULV concept of pesticide spraying, the development of low volume enhanced atomization of B.t., the development of improved formulations of B.t. against the spruce budworm, and the validation of the adulticide strategy for control of the spruce budmoth (Zeiraphera canadensis). The following is a brief account of the results obtained in these trials.

Spruce Budworm

1) The development of reduced diluent spraying (UULV) with TBM spray aircraft.

The development of UULV spray technology took place first with small agricultural type aircraft and was simply the application of development work done by Dr. Picot on efficient atomizer usage. Tests and operational trials in 1984, 85 and 86 clearly showed that the UULV application was as or more efficacious than the standard method of applying chemical sprays.

Based on this information and the development and commercial production of a reliable rotary atomizer (the Micronaire AU4000, capable of operating safely at high rpm's) Forest Protection Ltd. equipped three TBM aircraft with these atomizers (10 per aircraft). FPL sponsored a study to evaluate the performance of this spray system in an operational context. The evaluation was based on comparative deposit measurements in standard fenitrothion treatment blocks, and blocks treated with the Micronaire/TBM system at 140g/ha and others at 210g/ha of fenitrothion per ha.

The principle behind this is that the lower flow rate per nozzle allows the atomizer to rotate more rapidly hence providing

enhanced spray cloud formation with most of the droplets in the desired 50 to 20 micron range.

An attempt was made to sample as many sessions as possible. In all 22 spray session were sampled and five sets of samples consisting of five sets of trees per sample were taken. These samples were taken as soon after treatment as possible and transported to a storage freezer on dry ice. Chemical analysis was contracted through RPC.

Further, nine of the blocks examined were sampled by DNRE for efficacy. We are currently analysing this information in comparison to deposit.

Results: Based on statistical analysis no significant difference in deposit was detected between the three spray scenarios investigated although the 210 g/ha UULV provided the highest mean deposit.

Table 1

Treatment	N	Mean deposit on fir foliage ppm's
210 UULV	50	2.669
140 UULV	39	2.299
210 Standard	54	1.847

Tables 2 and 3. are provided to show differences between blocks, and treatments. From this preliminary analysis it appears that the development of large aircraft with rotary atomizer systems is feasible and this could translate more efficient spray systems.

Table 2

Summary of fenitrothion spray deposit (ppm) in all spray sessions sampled - TBM boom and nozzle vs TBM with micronaires.

Spray block	Lines	Deposit ppm's*		
		1st application	2nd application	Total
		210 g/ha in 1.4 L/ha		
A5	75-90	0.92	2.33	3.25
A5	91-108	-	2.15	-
A1	0-10	-	0.93	-
A2	21-31	3.05	1.14	4.19
A2	58-72	2.13	2.49	4.62
A8	60-90	3.17	1.08	4.25
A28	0-11	-	2.88	-
		210 g/ha in 0.4 L/ha TBM Micronaire		
A2	73-79	1.71	-	-
A4	25-50	4.04	3.33	7.37
A13	21-29	0.77	-	-
A13	35-50	5.99	-	-
A28	0-11	2.80	-	-
A9	105-109	0.95	-	-
A1	0-10	2.10	-	-
A6	0-11	1.09	3.91	5.00
		140 g/ha in 0.4 L/ha TBM Micronaire		
A6	37-94	1.66	1.00	2.66
A1	10-25	2.60	0.49	3.09
A11	0-15	1.40	1.38	2.78
A5	7-24	8.06	1.33	9.39

*each deposit measurement noted above is a mean deposit for 5 trees per five plots per treatment.

Table 3.
Analysis of spray deposit means using the Waller-Duncan K-Ratio T. test.

Treatment	N	Mean deposit	Significance Grouping
210 UULV 2nd app	10	3.619	A
140 UULV 1st	20	3.43	A
210 UULV 1st	40	2.42	A B
210 Std 1st	19	2.280	A B
210 Std 2nd	35	1.613	B
140 UULV 2nd	19	1.107	B

2) Biological Interface - Studies on the post-spray impact of weather on efficacy - B.t.

It has been postulated that immediate post-spray weather has a measurable impact on the efficacy of any spray session and that more efficacious sprays occur when post-spray weather tends to be dry and warm than when wet and cold (for simplicity's sake). Translation of this into any operational context awaits 1) the precise definition of the weather parameters that negatively impact on efficacy and 2) the ability to predict these weather events and integrate this information into spray operations.

Studies at the Canadian Forestry Service - Maritimes laboratory in 1986 and 1987 (Eidt/Kettela) are aimed at attempting to define the impact of post-spray weather on efficacy (larval mortality). A protocol developed in 1986, using replicate sets of seedling balsam fir infested with spruce budworm larvae and treated with the aid of a portable spray tower enabled us to treat sets of trees through a complete season and monitor closely weather at the time of treatment and for 96 hrs post-spray. The trials in 1986 with fenitrothion did not demonstrate that post-spray weather had a serious impact on efficacy, but that efficacy was more closely related to the amount of spray deposited on the foliage.

In 1987, similar studies were conducted using the B.t. insecticide FUTURA. Spray deposition was assessed using the bioassay technique developed by Thomas anbd Wiesner. Data analysis is underway and it is evident at this time that

1) B.t. activity on foliage drops very quickly in the 48 hr period post spray.

Bioassay Results, % frass inhibition post-spray		
1 hr	24 hr	48 hr
70%	40%	21%

(This confirms observations made by other researchers)

2) that of all the weather parameters measured rainfall has a measurable impact on efficacy;

	observations	% larval mortality
rain*	15	39
no rain**	11	69

*rain--at any time 48 hrs post-spray
**no rain-- no rain recorded 48 hrs post spray

3) that in the case of the no rain data set there is a clear relationship between increasing deposit (% inhibition) and increasing larval mortality, which confirms the validity of the bioassay technique for quantitative B.t. deposition analysis.

3) Reduced dosage of B.t. and efficient atomizer usage.

To capitalize on the wind tunnel work done at UNB by Dr. Picot FPL proposed a study to evaluate the standard method of applying B.t. sprays against one that would maximize rotary atomizer efficiency, and based on calculations, provide a similar number of spray droplets of B.t. through the application of significantly less volume of B.t.

Application of the B.t. was made with small agricultural type aircraft equipped with Micronaire AU 4000 rotary atomizers. Ten spray blocks of each treatment were sampled for efficacy and deposit. The dosage applied to each set of blocks was 15 biu/ha and 30 biu/ha. More importantly, the volume of spray emitted per spray nozzle head was 0.5 US gal and 1.525 US gal respectively. In the case of the reduced dosage and low flow rate, the blocks were flown 3 times to release the necessary spray volume. It was reasoned that the cost of repeated application would be more than offset by the reduced volume of and hence cost of B.t.

The Thomas/Wiesner bioassay method of quantitative B.t. deposit evaluation was used as well as dyed sprays on two blocks to provde the traditional droplet per needle information.
Results: The following table summarizes the results of this experiment. The reliability of the deposit bioassay is in question because of problems with the laboratory stock budworms used in the test so it is not included here.

Treatment	no. blocks	% Reduction survival	% Reduction defoliation
15 biu/ha 0.5 USG/head	10	81 (55-97)	55 (5-90)
30 biu/ha 1.525 USG/head	10	91 (80-90)	68 (35-90)

Although the results appear to be slightly enhanced in the higher dosage blocks statistically there is no difference between the treatments. In this initial trial and first run at data analysis, it appears that the question posed has validity and that similar efficacy can be obtained by maximizing nozzle efficiency and reducing dosage. Use of higher potency B.t.'s may offer a way of providing even more cost effective protection.

4) Trials with B.t. Products against larvae of the Spruce Budworm.

As part of a continuing program to evaluate new B.t. formulations, agreements were entered into with two manufacturers to appraise the field performance of their products. In the case of Abbott Laboratory we evaluated DIPEL 6L, 8AF, 8L and 12L, and with Chemagro, FUTURA XLV. These B.t. products were applied with aircraft equipped with Micronaire AU 4000 rotary atomizers. Results indicated that all products provided satisfactory levels of protection and is being used to support registration.

SPRUCE BUDMOTH CONTROL

1) Adulticiding program

In 1987 further field trials were conducted to evaluate the adulticide strategy for control of the spruce budmoth. Results from 1985 and 1986 were very encouraging in that infestation levels in the following year were depressed significantly by single and double applications of 105 grams fenitrothion per hectare. Similarly, tests with one application of 105 g/ha of fenitrothion resulted in a dramatic reduction of moth activity. Egg deposition in the treated areas is being evaluated, and damage levels will be measured in June of 1988.

2) Pheromones for control of Spruce Budmoth

This is the 2nd year of a 4 year study to develop pheromones for control of the spruce budmoth. The NB RPC is the key organization carrying out this work. Ground applications of two pheromone formulations, at a variety of dosages showed that trap catch disruption occurred. This encouraging result indicates that the next phase of the development should proceed, mainly an aerial application trial. This is being planned for 1988.

TERRESTRIAL IMPACTS

Fenitrothion Avian Impact

P. D. Kingsbury

In March of 1987 the chairman of the Atlantic Region Pesticide Advisory Committee (ARPAC) wrote to the New Brunswick and Newfoundland and Labrador Environment Departments to express concerns regarding the continued use of fenitrothion as a forestry insecticide. The primary concern raised was the impact of fenitrothion on songbirds, and the letter was accompanied by a two page "Fenitrothion Review" prepared by the Fredericton office of the Canadian Wildlife Service (CWS). The Forest Pest Management Institute responded to this development by preparing and distributing in April 1987 a position paper reviewing this issue (see EMOFICO 1987). I would like to briefly summarize the situation as we perceive it today at FPMI.

The stimulus for the ARPAC letter was a report prepared by Fudge, Lane & Associates Ltd. (1986) on the results of songbird brain cholinesterase studies carried out in a fenitrothion spray block during the 1986 hemlock looper control program in Newfoundland. THis study reported that a large proportion of the birds shot in this block after each of two fenitrothion sprays had brain cholinesterase (ChE) activity levels lower than birds of the same species collected from unsprayed areas. When data from both sprays were combined, 71% of the birds showed over 20% brain ChE depression and 38% showed over 50% depression. Comparing these results to previous studies (Table 1), it is apparent that they indicate a much greater degree of ChE inhibition than has generally been found after fenitrothion sprays applied at the same or even higher application rates elsewhere. Of particular interest is the difference between these results and those reported by Strong and Wells (1986) who carried out similar studies during the 1985 hemlock looper spray program in Newfoundland. They found only 7% of birds with 50% brain ChE depression after fenitrothion was applied at the same rate and with the same type of aircraft and spray emission equipment as in 1986.

What can we make of these unusual results? The authors themselves draw the conclusion that "the results from fenitrothion spraying events are largely descriptive of the individual spray event and evidence suggests that caution should be taken before claiming broad predictions of all fenitrothion spraying events from one monitored event" (Fudge, Lane & Associates, 1986). This is supported by a comparison of results

from different studies (Table 1). This table shows that substantially different degrees of brain ChE depression have been reported among songbirds sampled from spray blocks treated with the same nominal rate of fenitrothion. Higher application rates have not always been accompanied by greater cholinesterase depression than found after applications at lower rates. This brings into question the validity of statements by CWS Fredericton researchers in their "Fenitrothion Review" which suggest that overswathing causes major impacts on songbirds. Such statements ignore the host of other factors such as weather conditions, topography, height of spray release, height and nature of the forest cover, degree of canopy closure, activity of the songbird population at the time of and following spraying, and others. All of these can greatly influence the degree of exposure of birds to fenitrothion as much or more than an unintentional elevation of the application rate by overswathing.

Although it may be difficult to predict the extent to which a given fenitrothion application will depress the brain ChE activity of songbirds within a spray block, it is well established that many birds often experience a 20% reduction, and some birds experience a 50% reduction in the activity of this enzyme. The key question would then appear to be...What are the consequences to the survival and fitness of an affected bird of depressions to these extents? Brain ChE determination requires sacrificing the bird to remove its brain, so it is impossible to determine the cholinesterase inhibition in the bird and still measure the ability of that individual to recover from this effect. Cholinesterase inhibition is reversible and has been found to recover after exposure ends. Recovery is similar in a variety of bird species (Fleming and Grue 1981) and after single oral doses or prolonged dietary doses (Fleming 1981). Initial recovery of cholinesterase activity to about 50% normal levels is rapid, after exposure to organophosphates has ceased, following which recovery proceeds at a slower rate (Fleming 1981).

Cholinesterase inactivated by carbamate insecticides will spontaneously reactivate quite rapidly once the free inhibitor is no longer present (Martin et al. 1981), and consequently, recovery of cholinesterase activity is more rapid following exposure to carbamates than organophosphates. This is supported by Canadian field studies showing little evidence of inhibition of forest songbird brain cholinesterase following carbamate sprays (Table 2).

Table 1
Songbird Cholinesterase Responses following Forest Sprays with Fenitrothion

		No. of species studied	% of birds with ChE depression of: 20%	50%
N.B. 1980 - Busby et al. 1981				
280 g/ha	B+N	4	30	5
280 g/ha	RA	4	16	5
N.B. 1978/79 -Busby et al. 1983b				
210 g/ha	B+N	1	58	0
210 g/ha	B+N	1	50	7
210 g/ha	B+N	1	83	6
420 g/ha	B+N	1	95	25
Nfld. 1985 - Strong & Wells 1986				
210 g/ha	B+N	?	?	7
Nfld. 1986 - Fudge, Lane & Assoc.				
1986 unsprayed control		6	9	0
210 g/ha	B+N	3	76	55
210 g/ha	B+N	3	73	19
350 g/ha	B+N	2	71	43
N.B. 1986 - Busby et al. 1987b				
210 g/ha	RA	4	16	1

RA - rotary atomizer; B+N - boom and nozzle

Table 2
Songbird Cholinesterase Responses following Forest Sprays with Aminocarb and Mexacarbate

	No. of species studied	% of birds with ChE depression of: 20%	50%
Aminocarb (MATACIL)			
N.B. 1981 - Busby et al. 1982			
70 g/ha RA	5	4	0
N.B. 1982 - Busby et al. 1983a			
70 g/ha B+N	5	9	0
Mexacarbate (ZECTRAN)			
N.B. 1984 - Busby et al. 1987a			
unsprayed control	7	11	0
70 g/ha RA	7	11	1
140 g/ha RA	6	19	0

RA - rotary atomizer; B+N - boom and nozzle

The majority of research examining the effects of cholinesterase inhibition on birds has been done using oral or dietary dosing of laboratory species such as starlings, quail or ducks. Two widely cited criteria have evolved from this body of work:

> Cholinesterase depression of 20% or more in birds is considered to be indicative of exposure to organophosphate pesticides.
>
> (Ludke et al. 1975, Grue et al. 1983)
>
> Cholinesterase depression of 50% suggests a "life-threatening situation".
>
> (Zinkl et al. 1980).

Although these statements have been widely cited, neither is definitive. Many authors have failed to report the proportion of unsprayed control birds whose cholinesterase level is 20% lower than the mean for all unsprayed individuals, but two different Canadian field studies show about 10% of unsprayed birds fell into this category (see Tables 1 and 2). Zinkl et al. (1980) expanded on their statement of 50% depression being indicative of a "life threatening situation", adding that inhibition of at least 80% is required before birds will be killed by a single oral dose of an organophosphate insecticide, although death may occur with only 50% inhibition when continuous exposure through contaminated feed occurs. Other authors have shown that although birds that die from exposure to a cholinesterase inhibitor usually show at least 50% depression, similar inhibition in living birds does not necessarily mean those individuals will die (Ludke et al. 1975, Grue et al. 1983). Fleming (1981), in fact, turns the criteria around by stating that 50% inhibition is a minimum effect level in birds, as it also appears to be in mammals. He goes on to contend that since recovery to 50% normal activity occurs rapidly, effects are limited to a short period following significant exposure.

Does this mean that all birds whose brain cholinesterase is depressed by 50% or more exhibit severe behavioral effects. Again, a number of studies show this not to be the case. Even prolonged inhibition of over 50% may not be accompanied by symptoms, Miyamoto (1977) reports a study where Japanese quail feeding on a high dose (50 mg/kg) fenitrothion diet for four weeks had their brain cholinesterase activity depressed by over 50%, but suffered no behavioural or weight gain effects except for a temporary reduction in egg production. Fleming (1981) reviews a number of studies where dosed birds recover from peak inhibitions of cholinesterase activity of up to 90%. Evidence that forest passerines may also tolerate significant inhibition is implicit in that of the many birds found to have 50% ChE depression or greater following forest sprays with fenitrothion

(Table 1), none were reported to be displaying symptoms of distress and most were territorial males who were collected when they indicated their location by their apparently normal singing activities.

Given that it is impossible to precisely state the biological consequences of the levels of cholinesterase depression measured following fenitrothion sprays, what do we know about the effects of this insecticide on birds from other types of studies? Fenitrothion has had an extensive use pattern for controlling spruce budworm in Eastern Canada since the late 60's (Table 3). Over this period, a wide range of studies have been carried out by federal, provincial, university and private industry researchers. These studies have been reviewed and reported elsewhere (Peakall and Bart 1983, the FPMI position statement EMOFICO 1987), but I will briefly summarize their general findings.

Early studies by CWS Fredericton reported that the threshold application rate at which dead birds began to be found by post-spray casualty searches lay between 280 and 420 g/ha (Pearce 1968, Peakall and Bart 1983). In the mid to late 70's, when fenitrothion use was greatest and large monitoring programs were in place in a number of jurisdictions, almost all of the researchers involved failed to find any dead songbirds following operational programs applying 210 to 280 g/ha. A number of reports of songbird casualties during this period were investigated, but were found to be due to causes other than fenitrothion sprays (migration stresses coupled with severe weather, ingestion of ice-melting chemicals along roads). Following an application of 1400 g/ha of fenitrothion in an experimental block in Quebec, only three sick birds and no spray casualties were found in 25 hours of searching by experienced observers (Lehoux et al. 1982), despite foliage residues five times higher than normally found in operational spray blocks (Morin et al. 1986).

The main method employed in studying fenitrothion effects on songbirds has been short-term population censuses of breeding birds by territorial mapping or singing male counts. These studies have found that operational fenitrothion sprays do not cause major impacts on overall songbird populations. Furthermore, an extensive review by Peakall and Bard (1983) concluded that although moderate decreases in some species sometimes occurred at 280 g/ha, many canopy feeding species which would be exposed to the highest residue levels do not show significant decreases in areas treated with up to 560 g/ha. Lehoux et al. (1982) could not, in fact, find significant differences in pre-spray to post-spray changes in bird populations on a 1400 g/ha fenitrothion treated plot and an untreated control plot by either singing male counts or territorial mapping methods.

Table 4
Operational Use of Forest Insecticides in Eastern Canada in Recent Years[a]

	1000's of hectares sprayed[b]				
	1983	1984	1985	1986	1987
Spruce budworm only					
B.t.	64	376	644	336	403
Fenitrothion	1,553	687	352	222	342
Aminocarb	1,162	930	455	197	28
Total	2,779	1,993	1,451	755	773
All major forest insect pests[c]					
B.t.	64	376	868	906	551
Fenitrothion	1,553	687	475	301	504
Aminocarb	1,162	930	455	197	28
Total	2,779	1,993	1,798	1,404	1,083

[a] approximate figures compiled from Forest Pest Control Forum reports
[b] much of the area sprayed received a second application of the same or a different material
[c] spruce & jack pine budworms, gypsy moth, hemlock looper .

In addition to the evidence from short-term census studies indicating little impact, an analysis by CWS Fredericton of breeding bird surveys in New Brunswick for ten forest songbird species for the period 1967 to 1976 showed no downward trends during this period (Pearce et al. 1979). The authors conclude that any short-term impacts of fenitrothion had been compensated for by the natural resilience of songbird populations.

In light of the large body of accumulated evidence that fenitrothion has little effect on songbird populations, why the ongoing concern over this issue? It is true that songbird census techniques are stongly influenced by a number of factors which may limit their sensitivity for detecting pesticide impacts. It is also true, however, that songbird populations are highly resilient and easily capable of compensating for any losses which might occur undetected by census techniques. These levels of losses would, in fact, be modest in terms of losses from other natural and man-made causes such as migration mortality, collisions with automobiles, buildings or power lines, illegal hunting activities, loss of forest habitat through timber harvesting, urbanization or agricultural activities, and the actions of fire, insects and disease. It is highly questionable in view of the scientific evidence collected to date to suggest that the effects of fenitrothion spraying, undetectable at the population level as they are, might be the one additional stress which when combined with all others pushes songbird populations to the point of collapse.

In the "Fenitrothion Review" by CWS Fredericton, great emphasis is placed on research carried out by CWS in New Brunswick since 1978 on the effects of fenitrothion on White-throated Sparrows. These studies have focused on reproductive success and nestling growth and survival following operational or experimental sprays or after oral dosing of nestling or parent birds. Several conclusions are drawn from this work. Conventional 210 g/ha applications are claimed to have a "minimum impact of reduced growth and development of nestlings, which although apparently not sufficient to reduce fledging success, is adequate reason to cast doubt on post-fledging survival". The evidence for this statement appears to be a study carried out in 1978, summarized in an EMOFICO report (EMOFICO 1980) and cited in that report as Peters (1979). This undergraduate thesis (Peters 1979) is not available from the University of New Brunswick, where the work was carried out, or from any other source aside from people directly involved in the work. Although it represents an ambitious attempt to look at spray effects on nestling growth, critical review reveals major flaws in drawing the conclusion that it demonstrates such an effect. No significant difference in mean weight of chicks from sprayed and unsprayed plots was found at the end of the nestling growth period. The significant difference in growth rate claimed is only true for selected periods of growth for some clutches of birds (days 0 to 6 of the

8 to 9 day nestling period for first and unknown clutches, but not for second or first and second clutches combined). No significant differences in hatching or fledging success were found between sprayed and unsprayed plots. In short, the report does not support the claim made in the "Fenitrothion Review" that there is reason to doubt the post-fledging survival of nestlings because fenitrothion is retarding the growth of nestlings. Unless such research has been published in an openly available peer reviewed format, it should not be used in assessments of pesticide issues or the development of stances by advisory boards or panels.

Likewise, statements in the "Fenitrothion Review" of percent reductions in nesting success linked to a given level of cholinesterase depression have never been published with supporting data, or subjected to peer review, despite the fact that the conclusions were first made public in 1980. The authors have suggested that these studies are not suitable for publication in the open scientific literature, due to limitations in sample size, adequate controls and statistical validity. If this is the case, these findings should not be cited in regulatory positions without appropriate acknowledgments of their limitations. All these points aside, it would still seem the effects they claim accompany overswathing are of such a magnitude that it is highly improbable they would have gone undetected over the long period of fenitrothion use.

The Forest Pest Management Institute's Environmental Impact Project has been actively studying the effects of fenitrothion on forest avifauna since the early 1970's. Two recent and current major studies utilizing new methods to look at this question have confirmed our opinion, formed and tested over many years of census studies in experimental and operational spray blocks, that conventional fenitrothion applications do not significantly affect songbird population dynamics in treated forests. Current laboratory studies with a small cagebird species (Zebra finch), comparable in size to many forest passerines, are exploring the effects of various degrees of fenitrothion induced cholinesterase inhibition on behavior and reproduction. Results to date have confirmed that only slight or transient effects, expressed as reduced activity and no mortality, were associated with induced depression of ChE of 50%. In a second group of mated pairs whose ChE was depressed by 70%, mortality was limited to 2 of 48 birds. Although activity in this group was severely depressed for a period of about two days, reproductive success was not severely affected. These studies are ongoing and will form the basis of a M.Sc. thesis to be completed in the near future. In a second study carried out in the field from 1983 to 1987, census, netting, banding, time-budget, food availability and residue studies were combined to evaluate effects of 280 g/ha fenitrothion applications. Despite the intensity of these studies, little evidence of impact was found. The results of

this study have been presented in a M.Sc. thesis which was successfully defended in December of 1987, and publication of this work is currently being pursued.

In summary, there is a great deal of evidence to show that fenitrothion does not pose a major threat to the stability of forest songbird populations. There remains, however, conclusive field evidence that fenitrothion sprays routinely reduce brain cholinesterase levels in some individuals. The biological significance of these depressions remains an area of question, and reasonable concerns over this effect are valid considerations for researchers and regulators alike. Considerable action has been taken to limit this area of potential hazard by reducing both the amounts and proportions of fenitrothion spraying relative to the use of other insecticides (B.t. and aminocarb) which are known to pose less hazard to songbirds (Table 4). Unfortunately, the list of alternatives available is short, and with the current lack of availability of aminocarb, is limited to B.t.. Fenitrothion remains the most effective, practical and economic control option for some forest pests. FPMI supports the use of alternative control measures in situations where they can meet forest protection objectives with more limited hazard to songbirds. On the other hand, in situations where fenitrothion is the most suitable control option, we feel that the degree of hazard to songbirds posed by its use is insufficient to preclude its choice and application.

Table 3
Operational Use of Insecticides to Control Spruce Budworm
in Eastern Canada, 1965-1987[a]

		1000's of hectares sprayed[b]				
Insecticide	Period used	65-69	70-74	75-79	80-84	85-87
DDT	1944-1969	1,800	-	-	-	-
Phosphamidon	1963-1977	750	2,550	3,950	-	-
Fenitrothion	1967-1987	1,400	12,800	13,900	7,900	916
Aminocarb	1970-1987	-	650	8,500	4,100	680
B.t.	1974-1987	-	5	40	520	1,383
Hectares sprayed per year		790	3,201	5,278	2,504	993

[a]approximate figures compiled from Forest Pest Control Forum reports
[b]much of the area sprayed received a second application of the same or a different material

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THE EFFECT OF FENITROTHION, APPLIED BY ROTARY ATOMIZER-EQUIPPED TBM AIRCRAFT, ON BRAIN CHOLINESTERASE ACTIVITY IN FOREST SONGBIRDS

D. G. BUSBY AND P. A. PEARCE

Advances in spraying technology to enhance the effectiveness of forest insecticides, particularly when there is a potential for significantly reducing the dosage rates of active material, are to be encouraged. It is desirable that the control advantages conferred are accompanied by decreased hazards to the environment. Fenitrothion has been used for many years in aerial spray operations against spruce budworm. Departures from the traditional mode of fenitrothion use in New Brunswick have included experiments involving different spray aircraft types, emission hardware, and manner of insecticide formulation. Since, at least in the view of CWS, there are questions concerning the acceptability of fenitrothion because of hazards to forest songbirds, it was deemed important to be assured that significant

changes from the traditional manner in which fenitrothion has been used did not further compromise the welfare of birds. Thus it was that in 1987 CWS undertook a study in New Brunswick to assess responses of birds to fenitrothion delivered by rotary atomizer-equipped TBM aircraft. The work was done in the context of efficacy studies conducted by NBDNRE.

Spray impact was evaluated by comparing brain cholinesterase (ChE) activities of exposed and control birds.

Study Area and Methods

The study area was located in northwestern New Brunswick, near Kedgwick. Two areas within two specific spruce budworm spray blocks were selected for investigation: Block A-4, flight lines 41 to 55, which was scheduled to receive two treatments at the AI rate of 210 g/ha, and Block A-6, flight lines 11 to 22, which was to receive two treatments at the AI rate of 140 g/ha.

Four species of songbirds were studied in each area: tennessee warblers, representative of the upper canopy foragers; bay-breasted warblers, representative of the mid-to-upper canopy foragers; magnolia warblers, representative of the mid-to-lower canopy foragers; and white-throated sparrows, a low canopy-to-ground level forager. Birds were collectyed for ChE analyses by shooting (.410 shotgun). Sampling was to have been done, for each of the four sprays (i.e. two sprays in each of the two blocks), on the day of spray (Day 0), the day following the spray (Day 1), and Day 3. However, due to same-day spraying in the two blocks and to last minute changes in spray plans by Forest Protection Limited, our field crew was able only to incompletely sample Block A-6. A sampling objective on all but five samplings, and on three of those nine birds were collected.

Results

Brain cholinesterase activity in all species and for all samples was inhibited (Table 1). Mean ChE activities were significantly lower than controls in 26 of the 32 post spray samples. The limited data from Block A-6 (the low dosage block) indicate that birds were affected to approximately the same degree as in Block A-4. The percent of individual birds exhibiting ChE inhibition in excess of 20% and 50% of the control means is given in Table 2.

Table 1. Mean brain cholinesterase activity (mu/mg brain) in forest songbirds: comparison of means of unsprayed samples and samples collected in two blocks sprayed with UULV fenitrothion.

Species	Controls	Block	Exposed					
			Day 0	Day 1	Day 3	Day 0	Day 1	Day 3
Tennessee Warbler	29.7	A-4	27.0	19.5[1]	18.6	26.5	26.7	22.5
		A-6	----	21.1	19.3	----	----	----
Bay-breasted Warbler	29.7	A-4	29.4	23.1	23.7	25.9	24.7	21.0
		A-6	----	20.2	22.3	----	----	----
Magnolia Warbler	30.3	A-4	28.0	20.9	22.9	26.8	24.4	25.3
		A-6	----	25.9	24.3	----	----	----
White-Throated Sparrow	30.2	A-4	24.0	19.3	11.3	25.6	19.8	17.4
		A-6	----	19.5	20.1	----	----	----

[1] Underlined figures are statistically different ($P<0.05$) from controls, Mann-Whitney U-test.

Table 2. The percent of songbirds collected from Block A-4 and A-6 exhibiting 20% and 50% brain cholinesterease inhibition compared to control means.

Species	Block A-4		Block A-6	
	20%	50%	20%	50%
Tennessee Warbler	46	13	67	19
Bay-breasted Warbler	39	6	75	10
Magnolia Warbler	34	20	35	15
White-throated Sparrow	70	29	83	26
All species	48	17	66	18

Discussion

Although the results of this study are only preliminary, they indicate that both spray dosages caused an impact on songbirds that exceeded any other seen by us in an operational context in New Brunswick since 1978, when ChE analysis became the standard for impact assessment. The levels of ChE depression in this study are comparable to those found in an earlier study which indicated severe effects on the reproduction and behaviour of white-throated sparrows (Pearce and Busby 1979).

The specific cause of the high level of impact can only be speculated upon. The UULV approach is probably not responsible as a previous study (Busby *et al.* 1987) found that UULV fenitrothion applied by Cessna aircraft equipped with rotary atomizers induced only minor effects on brain ChE activity in songbirds. The two differences in the 1987 work are that the spray was applied by TBM aircraft and the formulation was altered (in 1986 60% Dowanol^{R} and 40% technical fenitrothion; in 1987 40% water and 60% emulsifiable concentrate consisting of 70% technical fenitrothion, 10.5% Dowanol^{R}, and 10.5% Atlox^{R}). Other causes may relate simply to atmospheric events which caused higher-than-normal deposition to occur. Unpublished data (E. Kettela, pers. comm.) indicate that deposition in parts of Block A-4 was among the highest recorded (during the 1987 season).

Although efforts to reduce amounts of active ingredients in spray formulations are desirable from an environmental standpoint the results of the present study indicate that those changes will not necessarily lower the hazard to songbirds. Further, regardless of the precise causes of the impact, the results presented here reinforce our view that fenitrothion's margin of safety to songbirds is narrow.

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ASSESSMENT OF THE VARIABILITY OF FENITROTHION DEPOSITS ON CONIFER FOLIAGE FROM A FORESTRY SPRAY PROGRAM

W. L. Pierce and W. R. Ernst

ABSTRACT

Aerial applications of pesticides can result in target deposits which vary greatly in magnitude. As part of the 1987 Newfoundland and Labrador hemlock looper (Lambdina fiscellaria fiscellaria) spray program, a study was undertaken to determine the variability of spray deposit within spray blocks, between spray blocks, and the frequency of higher than acceptable deposit.

Foliage samples were collected from six operational spray blocks which were treated with an oil formulation of fenitrothion at a rate of 210 g a.i./ha by DC-6 aircraft. Foliage samples from each block (10) were taken on transects, which spanned three aircraft spray widths.

The measured deposits in foliage were highly variable between individual samples within spray blocks and between spray blocks. The data indicates that deposits of greater than five times the mean deposit concentration could be expected over up to 5% of the spray area. In addition, one block in six had mean deposit concentrations which were significantly higher (by a factor of 2) than the mean deposit for all six blocks. The magnitude of measured deposits were very similar to those measured in other jurisdictions where spray is delivered by large aircraft, but approximately twice the magnitude of deposits associated with small aircraft spraying.

PROGRESS REPORT OF 1987 FIELD EXPERIMENTS ON UULV FENITROTHION DEPOSITION IN BUDWORM MICROHABITAT AND BUDWORM LARVAL BEHAVIOUR

P.C. NIGAM AND S.E. HOLMES

Introduction

Budworm larvae in the balsam fir live within the confines of webbed microhabitats at the time of 1st and 2nd spraying of fenitrothion (Nigam 1986). In the summer of 1986, it was found that 210 g AI/ha of fenitrothion in ultra ultra low volume (UULV) was more effective for foliage protection and larval mortality than the same amount of active ingredient per hectare of emulsion (E.C.) formulation (Kettela, E.G., personal communication). When the webbing from treated microhabitats was chemically analysed about 2 to 10 times more fenitrothion was found in samples from the UULV plot than from the E.C. plot (Nigam 1987).

In 1987, the droplet spectrum of UULV droplets reaching the webbing was characterized and webbing was analysed chemically for the presence of fenitrothion; preliminary results and observations are summarized in this report.

Method and Material

The experiments were carried out at Dunphy, N.B. Thirty-two trees were selected in treatment and check plots. There were sixteen trees in the fenitrothion UULV treatment plot and 16 trees in the fenitrothion UULV treatment plot and 16 trees in the check plot. There were 4 replications and one tree was used for each quadrant. One 45 cm branch was sampled from each quadrant and 10 microhabitats with webbing were selected randomly for extraction of webbing for chemical analysis and 4 webbed microhabitats were used for counting and sizing of droplets on the webs. The webbed microhabitat samples for physical measurements of droplets were taken after 30 minutes of spraying and sampling was finished within an hour or earlier. Fenitrothion formulation, spraying parameters, population level and weather details are given in Table 1. Spraying was carried out by Forest Protection Ltd. under the technical supervision of Mr. E. G. Kettela of Canadian Forestry Service - Maritimes. Chemical analysis was carried out by New Brunswick Research and Productivity Council using Hewlett Packard 5840 gas chromatograph equipped with NP detector and autosampler.

The examination and sizing of droplets on webbing within the budworm microhabitat were done by using an operating microscope and video-microscaler. Some droplets were video taped.

Results and Discussion

Results of chemical and physical analyses of fenitrothion deposits are summarized in Table 2. Both types of analysis show the same trend in deposit and results appear to be complementary. Droplet spectrum observed on webbing of the microhabitat is given in Fig. 3.

Droplets 6-85 um were found on webbing. In Spray 1 more droplets were in the range of 20-45 um and in Spray 2, 15 to 40 um, with peak appearing between 35-40 and 20-25 um in Sprays 1 and 2 respectively. The mean amount of fenitrothion per microhabitat was approximately 39 ng in Spray 1 and 10 ng in Spray 2. On the average, there were approximately 2.2 droplets per microhabitat in the first spray and 1.2 droplets in the second spray.

Budworm larvae during the first spray were at the base of swelling buds, and during the second spray they were inside the growing buds which were heavily webbed. Larvae had more chance of coming into contact with fenitrothion on contaminated webbing than on contaminated needles, because they live within the webbing and constantly rub their cuticle and setae agains them. Fenitrothion deposits on webbing should be more effective in population reduction than deposits on old foliage.

References

Nigam, P.C. 1986. Budworm behaviour and their microhabitats in balsam firm during spray operations. Proc. 46th Ann. Meet. Acadian. Ent. Soc. p.15

Nigam, P.C. 1987. Dose transfrer and spruce budworm behaviour during operationsl application of fenitrothion. Proc. Symp. on Aerial Appl. Pesticide in Forestry (in press).

Table 1. Details of UULV application (Block 142, 1987)

Block size:	354 ha	
Formulation:	40% fenitrothion + 60% Dowanol with 1% Dupont oil red dye	
Application rate:	210 g AI in 0.45 L/ha	
Aircraft		
Type:	C-188 Ag truck (1)	
Speed:	160 km/h	
Atomizers:	4 x Micronair AU4000, set for maximum RPM	
	Spray 1	Spray 2
Date and time:	May 26, 0704-0736h	June 2, 0811-0840h
Wind direction and velocity (canopy level)	NW, 1-6 km/h	E, 1-7 km/h
Temperature (canopy level)	9-13°C	10-15°C
R.H.	n.a.	80-90%
Larval/branch	7.2 (pre spray)	-
Instar distribution		
Pupae/branch	-	0.2 (post spray)
Percent survival	-	7.2 (post spray)
Percent defoliation	-	12 (post spray)
Defoliation (1986)	-	-

Table 2. Fenitrothion deposits in spruce budworm microhabitats (Balsam fir, 1987).

Sample	Plot	Chemical Analysis			Physical analysis	
		Number of branches	Number of micro-habitats	Mean fenitrothion concentration (ng/ml) per 10 microhabitats	Number of micro-habitats	Number of droplets observed
Pre spray 1	UULV	3	25	5.9		
Spray 1	UULV	16	154	77.9	64	141
	Control	16	152	1.8		
Pre spray 2	UULV	3	30	1.7		
Spray 2	UULV	16	149	20.9	64	79
	Control	16	156	1.3		

SPRAY WEATHER DOCUMENTATION

R.B.B. DICKISON

Research coordinated by the NB Spray Efficacy Research Group (NBSERG) has included a component on spray weather documentation by a mobile atmospheric sounding system (minisonde) to measure wind and temperature within the lower few hundred metres. During 1981-1987 a total of 526 minisonde soundings were conducted in support of experimental trials and operational spraying (Table 1).

A review of these operations was presented at the NRC/CFB Symposium in Ottawa in October 1987 (R.B.B. Dickison and B. G. Steeves). The method allows an estimate to be made of the thermal stability contribution to atmospheric turbulence, an important factor in estimating deposition efficiency. Although the method is a crude alternative to that using elaborate tower-based measurements conducted by the National Research Council in the NBSERG Dunphy experiments, the review showed that the estimate of stability was within one Pasquill-Gifford class in 90% of the cases studied. The method also allows a determination of mixing depth and/or inversion base, which is often not possible otherwise. This is an important consideration in evaluating the contribution to long-range drift from an aerial spray operation.

Analysis of over 1000 minisonde soundings conducted in New Brunswick in support of spraying, moth dispersal and pollutant dispersal has allowed an excellent record to be compiled of the climatology of low-level summer atmospheric conditions-especially of the time variability during the early morning and early evening periods.

Table 1. Minisonde operations in support of spruce budworm spraying trials and operations in New Brunswick, 1981-87.

Year	No. of ascents	Site	Comments
1981	85	Dunphy	Spray drift and deposit trials
1982	38	Magundy	Operational experiment (chemical insecticide)
	69	Dunphy	Spray drift and deposit trials
1983	62	Priceville	Operational experiment (chemical insecticide)
	50	Dunphy	Spray drift and deposit trials
1985	36	Various	Operational experiments (airborne drift)
1986	29	Various	Operational experiments (chemical insecticides and Bt)
	35	Dunphy	Spray drift and deposit trials
1987	6	Dunphy	Experimental spray (pheromone)

AQUATIC IMPACTS

Using Fugacity to Assess Hazards of Pesticides; Do Aquatic Toxicologists Agree?

L. E. Burridge, K. Haya and V. Zitko

Models based on physical chemical properties of chemicals have been suggested for estimating the environmental fate of chemicals (MacKay 1979, MacKay and Paterson 1981, 1982). Zitko and McLeese (1980) modified a level I fugacity model in order to estimate the hazard of forest spray pesticides to aquatic fauna.

In 1986 we used the approach of Zitko and McLeese to assess the hazard of pesticide use in Prince Edward Island, Canada to the aquatic environment in that province (Burridge and Haya in press). The results were tabulated and the pesticides ranked in decreasing order of hazard. We then decided to compare these results to the "intuitive" assessments of individuals working in the field of aquatic toxicology. There is little agreement between fugacity model ranking and that submitted by respondents. There is also no agreement between groups of respondents. The results show a need for standardized methods of hazard assessment.

Table 1. Number of rankings, overall mean and rank, and fugacity ranking of pesticides used in survey (1=most, 20=least hazardous).

Pesticide	Group I		Group II		Group III		Overall			Fug.
	n	rank	n	rank	n	rank	n	mean	rank	rank
bensulide (Ben)	7	17	8	17	1	19	16	7.6	19	16
dicofol (Dic)	8	10	9	12	3	9	20	11.1	10	12
deltamethrin (Del)	8	2	9	4	2	10	19	15.1	2	14
trifluralin (Tri)	8	19	9	13	2	18	19	8.3	17	9
cypermethrin (Cyp)	9	8	9	5	2	16	20	13.5	8	7
thiram (Thi)	7	14	9	15	3	11	19	9.7	14	18
endosulfan (End)	9	5	9	1	4	5	22	15.7	1	6
methidathion (Met)	7	12	8	8	2	17	17	12.1	10	3
fluazifop-butyl (Flu)	6	15	7	16	2	20	15	8.1	18	20
dinoseb (Din)	8	6	9	6	2	1	19	14.7	4	8
chlorpyrifos (Chl)	9	3	9	2	3	12	21	14.6	5	1
methoxychlor (Mex)	9	9	9	9	5	4	23	13.4	9	13
azinphos-methyl (Azi)	9	1	9	10	2	3	20	14.2	6	2
chlordane (Chd)	9	4	9	7	4	2	22	14.9	3	5
phosalone (Pho)	8	11	8	14	2	15	18	10.4	13	17
malathion (Mal)	9	18	9	11	5	6	23	10.6	12	10
phorate (Phr)	9	7	9	3	2	13	20	14.1	7	4
captifol (Caf)	9	16	8	18	3	7	20	8.7	16	19
captan (Cap)	9	13	8	20	1	8	18	9.1	15	11
dodine (Dod)	6	20	8	19	2	14	16	6.7	20	15

Perturbation of the Aquatic Invertebrate Community of Bog Ponds by Fenitrothion and Aminocarb

W. L. Fairchild and D.C. Eidt

In June of 1984 and 1985, fenitrothion was applied experimentally to acidic (pH 4) bog ponds at operational rates for forestry of two-times 210 g active ingredient per hectare. Maximum recorded postspray insecticide residue concentrations in water ranged from 42 to 81 ug/L. These concentrations are within the range expected from direct operational spraying of shallow standing water. Six weeks after spraying, concentrations in water ranged from non-detectable to 0.06 ug/L. However, residue traces reappeared one year after spraying in water (0.3 ug/L), sphagnum moss (8-10 pg/g), and sediment (<0.01 pg/g). Total aquatic insect density was reduced and took over 12 months to return to control densities. Nematodes and annelids became more abundant after spraying, while most insects became less abundant. Chironomids and ceratopogonids, which were numerically dominant, had their abundance reduced by more than half. Other insect groups most affected include Coleoptera, Hemiptera, and Odonata. Gyrinidae, initially eliminated by spraying, increased above prespray levels by the end of summer.

In 1985 a similar study was done using aminocarb. Peak concentrations measured in water were about 76 ug/L and dropped below detectable levels one to three weeks after spraying. It was found that bog ponds are midly sensitive to formulated aminocarb at concentration ranges triple what might be expected from direct application at operational emmission rates of 70 g a.i./ha. The two groups most affected by the treatment were the certapogonids and chironomids. Both had recovered to reference densities within six weeks after treatment. Effects of aminocarb at operational rates would be expected to be very small and transient.

HERBICIDES

SUMMARY OF DNRE'S 1987 HERBICIDE WORK

M. BARTEAUX

A. Experimental

-In June DNRE contracted a Rockwell Thrush from Cedar Brook Farms Ltd. to carry out an experimental aerial herbicide application to a recent full tree logged area for the purpose of controlling the overstocked balsam fir regeneration. Roundup was applied @ 7 litres per hectare on 13 hectares near Mud Lake (2 miles SE of Nashwaak Lake). Early assessments show damage to the balsam fir but the damage does not appear permanent. A formal assessment of area will be carried out in June of 1988.
-Results of Velpar and Pronone trials carried out in 1985 and 1986 will be reported in 1988.

B. Operational

-DNRE aerially treated approximately 15 537 hectares of plantations and 3 408 hectares of natural cutovers on Crown Land along with 300 hectares of woodlot owner plantations for the Southern N.B. Wood Co-operative.
-Vision was applied at rates of 3.7 to 4.9 litres per hectare in a total spray solution of 37 litres per hectare.
-Three Bell 206B Jet Rangers from Trans Maritime Helicopters, one from Trans Canada Helicopters and two Rockwell Thrushes from Cedar Brook Farms were contracted to carry out the application. Approximately 2 200 hectares were contracted out the J.D. Irving Ltd.
-Spraying commenced on August 11th and finished on September 19th.

C. Monitoring

-Pre spray surveys were completed in the proposed 1987 spray blocks in July. Post spray surveys will be conducted next year to determine spray efficacy.
-The magnitude of softwood growth response from older spray operations will be reported in 1988.

MEASUREMENT OF THE ENVIRONMENTAL EFFECTS ASSOCIATED WITH FORESTRY USE OF ROUNDUP [R]

W. R. Ernst, R. Morash, W. Freedman,

K. Fletcher, G. Julien, P. Hennigar

ABSTRACT

Herbicides are becoming an increasingly popular tool in forestry for the control of competitive vegetation. Roundup [R], which contains the active ingredient glyphosate, is now the herbicide used almost exclusively for this purpose. The data base on the environmental effects of glyphosate is much smaller than that of the chlorophenoxy herbicides which were previously commonly used. Accordingly, a number of studies were undertaken to determine the environmental effects of Roundup [R] and, in some instances, to compare these effects with those documented for 2,4-D and 2,4,5-T.

The deposit of ground and aerially applied glyphosate on flat plates was measured using rhodamine dye as a tracer. Applications were at normal and twice normal operational dosage rates. Deposit was highly variable. However, ground applications provided the highest rate of deposit inside the target area with no measureable off-site deposits. Aerial sprays resulted in measureable deposit up to 95 metres off target.

The persistence of glyphosate on foliage and litter from aerially sprayed plots was also measured. Foliage selected for study were from red maple (Acer rubrum), balsam fir (Abies balsamea), raspberry (Rubus spp.) and grasses (Posceae and Cyperaceae). Highest concentrations of glyphosate were detected the day after spraying in raspberry and grasses (13 and 12 ug/g dry weight respectively). Red maple, forest litter and balsam fir had smaller concentrations of 5.1, 2.6 and 0.09 ug/g dry weight, respectively, one day after spray.

Residues in all substrates, with the exception of forest litter, declined rapidly up to the last day of sampling, 58 days post spray. Forest litter residues demonstrated an overall decline, however, the rate was less rapid than in foliage.

The rate of decomposition of litter, both in the field and in the laboratory, after treatment with herbicide was also explored. Substrates studied were forest floor material (litter, duff and humus), and fresh foliage from red maple or white spruce (Picea glauca). Samples of substrate were either dosed in the laboratory or placed in field plots which were subsequently sprayed with herbicide. The amount of substrate decomposition

decreased with increasing dosages of 2,4-D, 2,4,5-T, a 50:50 mixture of 2,4-D and 2,4,5-T, and glyphosate. These effects, however, were only signigicant at concentrations greater than 1000 ug/g. Such concentrations are considerably in excess of those associated with operational spraying.

The final study determined stream residue concentrations following direct oversprays at operational dosage rates of glyphosate and evaluated whether such concentrations affect stream periphyton abundance. Artificial substrates were placed in a stream above and below the target area, sampled at various times after spray and analyzed for chlorophyll a, phaeophytin, biomass and ATP content. Stream residues were highly variable immediately after spray with the highest concentration (39 ug/L) being measured 30 hours post spray. While periphyton abundance was variable, no changes which could be attributed to pesticide effects were noted for the study period which concluded 37 days after spraying.

OPERATIONAL HERBICIDE RESEARCH CONDUCTED BY FPMI IN 1987

P. E. Reynolds, D. Pitt, M. Roden and K. Buko

New operational herbicide research carried out by FP-54-1 in 1987 was conducted in northwestern New Brunswick in cooperation with DuPont Canada, Inc. and J. D. Irving, Ltd. This work involved research with VELPAR ULW, a new dry-flowable granular formulation of hexazinone. In addition FP-54-1 installed treatment blocks for a proposed brush herbicide trial, also in New Brunswick. This proposed trial is targeted to proceed in the summer of 1988.

Finally, FP-54-1 continued to collect follow-up data (i.e. weed efficacy, crop tolerance and crop growth) for herbicide trials previously established in 1984 and 1986. These included VELPAR L (liquid hexazinone) and VISION (glyphosate) trials established in New Brunswick and British Columbia in 1984 and hexazinone (PRONONE and VELPAR L), metsulfuron-methyl (ALLY) and sulfometuron-methyl (OUST) trials established in New Brunswick and Ontario in 1986. PRONONE is a granular formulation of hexazinone.

VELPAR ULW Research:

VELPAR ULW is DuPont's newest formulation of hexazinone, consisting of ultra low weight dry flowable granules of the herbicide. A comparative weed efficacy, crop tolerance, crop growth trial of VELPAR ULW versus VELPAR L (liquid formulation) was initiated near the Boston Brook airstrip (J.D. Irving, Ltd.

freehold land) in late June 1987. VELPAR L is temporarily registered for ground forestry applications, and is expected to receive a permanent registration, inclusive of aerial, soon. The purpose of the trial was to compare the overall desirability of the two formulations when applied aerially. Because of its light weight, the ULW formulation is expected to be less costly to apply operationally than VELPAR L. Data collected in 1987 (Pitt et al., 1988a), 1988 and 1989 will be used to support registration of the ULW formulation.

OUST, ALLY, PRONONE Research:

After two full growing seasons, soil-applied OUST continued to show acceptable levels of raspberry and grass control, whereas control of these species declined markedly after one growing season for soil-applied ALLY (Reynolds et al., 1988a). PRONONE, a granular formulation of hexazinone, continued to perform in a comparable manner to VELPAR L (Reynolds et al., 1988b). Fall soil treatments of both hexazinone formulations as well as summer foliar treatments with OUST and ALLY resulted in acceptable weed efficacy after one growing season. None of the herbicide treatments resulted in unacceptable crop injury. Although further evaluations are needed for 1988, preliminary results suggest that OUST (300 g ai/ha) is a viable alternative to hexazinone as a soil-applied site preparation herbicide and to glyphosate as a foliar-applied conifer release herbicide for raspberry and/or grass control.

Enhanced Crop Tree Growth Resulting from VELPAR L Treatment:

Bareroot white spruce trees planted in 1985 following a 1984 soil-applied VELPAR L treatment (i.e. cooperative study with DuPont Canada and J.D. Irving, Ltd.) grew dramatically in response to the treatment (Pitt et al., 1988b). Trees planted in treated and untreated plots were compared statistically for their health, condition, total height, height increment and basal stem diameter. Results of this analysis confirmed that those trees planted in treated plots were healthier and grew significantly more for all growth parameters measured than their counterparts planted in untreated plots. Enhanced growth of trees planted in VELPAR treated plots was positively correlated with the establishment of fireweed and the displacement of raspberry caused by VELPAR treatment. By contrast, untreated plots were characterized by a presence of raspberry and an absence of fireweed. Enhanced tree growth is probably attributable to fireweed mediated nitrogen fixation. In addition, once established, fireweed may also act to biologically control raspberry by making the microsite environment less suitable for the survival of this species. Further research on actual nitrogen fixation rates and on the effects of eliminating fireweed cover (i.e. half of the research site retreated was with glyphosate in August 1987) is planned for 1988. Crop tree growth

will continue to be monitored in 1988 and thereafter to establish whether the elimination of fireweed cover leads to a decreease in crop growth.

Carnation Creek Glyphosate Research:

The 1987 field season for FP-54-1 concluded with a third year vegetation assessment of the CArnation Creek watershed, located on the west coast of Vancouver Island. The watershed was treated in 1984 with glyphosate. Data collected in 1987 will be incorporated into a silviculture paper (Reynolds et al., 1988c) to be presented at the Third Carnation Creek Workshop to be held this December 8-10 in Nanaimo, B.C. The workshop will focus on glyphosate environmental impact research conducted at the watershed since September 1984.

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SOFTWOOD GROWTH RESPONSE STUDY AFTER ROUNDUP TREATMENTS

M. MacDonald

INTRODUCTION

Very few studies have been undertaken or results documented on softwood growth response to Roundup treatments in New Brunswick. Roundup, or Vision as it is known now, has only been registered for aerial plantation tending since 1984 and therefore only a three year maximum response could be measured on DNRE's operational areas. It has, however, been used experimentally since 1978 so there are areas where potentially older growth data could be obtained.

In these experimental applications, no parts of the targetted plantations were left as control. Timber Management Branch was more concerned with the immediate efficacy of the product on the unwanted species rather than the measurement of the long-term growth benefits the softwood stock would produce. The only way in which control areas could be incorporated into this study were to choose areas which had a sufficient amount of green strips or missed spray swaths so that an equal number of control and treated plots could be established.

After tedious investigation, Timber Management Branch found five plantations which fit the criteria, two jack pine and three black spruce. The growth response periods (years since herbicide treatment) range from 2 to 9 years.

METHODS

Five to six circular plots in the control strips and the same number in the sprayed areas were permanently established in each plantation. These plots measured .02 hectares in size. The heights of only the planted crop trees were measured on each plot in 4 of the 5 plantations. In the other plantation, Timber Management Branch decided to measure the diameter of each tree 6" above ground as well as their heights in order to determine a relative volume response.

The average number of trees and the average height per tree were calculated for the control and treated areas and reported in Table 1. The average number of trees was converted into per hectare values. In an area at Wildcat Brook, the average diameter of the trees in the two different treatments was also calculated and an average volume index was computed using this simple formula developed by Perry, 1964:

$V = D^2H$ where V = relative volume
D = diameter 6" above ground line
H = total height

The increase obtained in the parameters measured for the treated areas was expressed relative to the control areas for each plantation, which in this process acquired the base value 0 and is shown in Figure 1.

RESULTS

Without herbicide treatment, stocking is decreased through seedling mortality directly related to the effects of competition. In one instance (Wildcat Brook), the untreated area only had 300 trees per hectare left at age 11 while the treated portion had a very acceptable 2,000. In 4 of the 5 plantations, this trend is evident.

In every plantation, the average heights of the planted softwood stock were greater in the sprayed than the unsprayed areas, ranging anywhere from 12 to 227 percent greater.

At Wildcat Brook, the average relative volume index of the sprayed area was 47 times greater than in the control areas, only 7 years after treatment.

Perry, T.O. and A. Y. Roberts, 1964.
Volume formulas for loblolly pine seedlings in the vicinity of Raleigh, North Carolina. Journal of Forestry. March: 186-187.

Table 1.

CROP TREE GROWTH RESPONSE TO ROUNDUP TREATMENTS

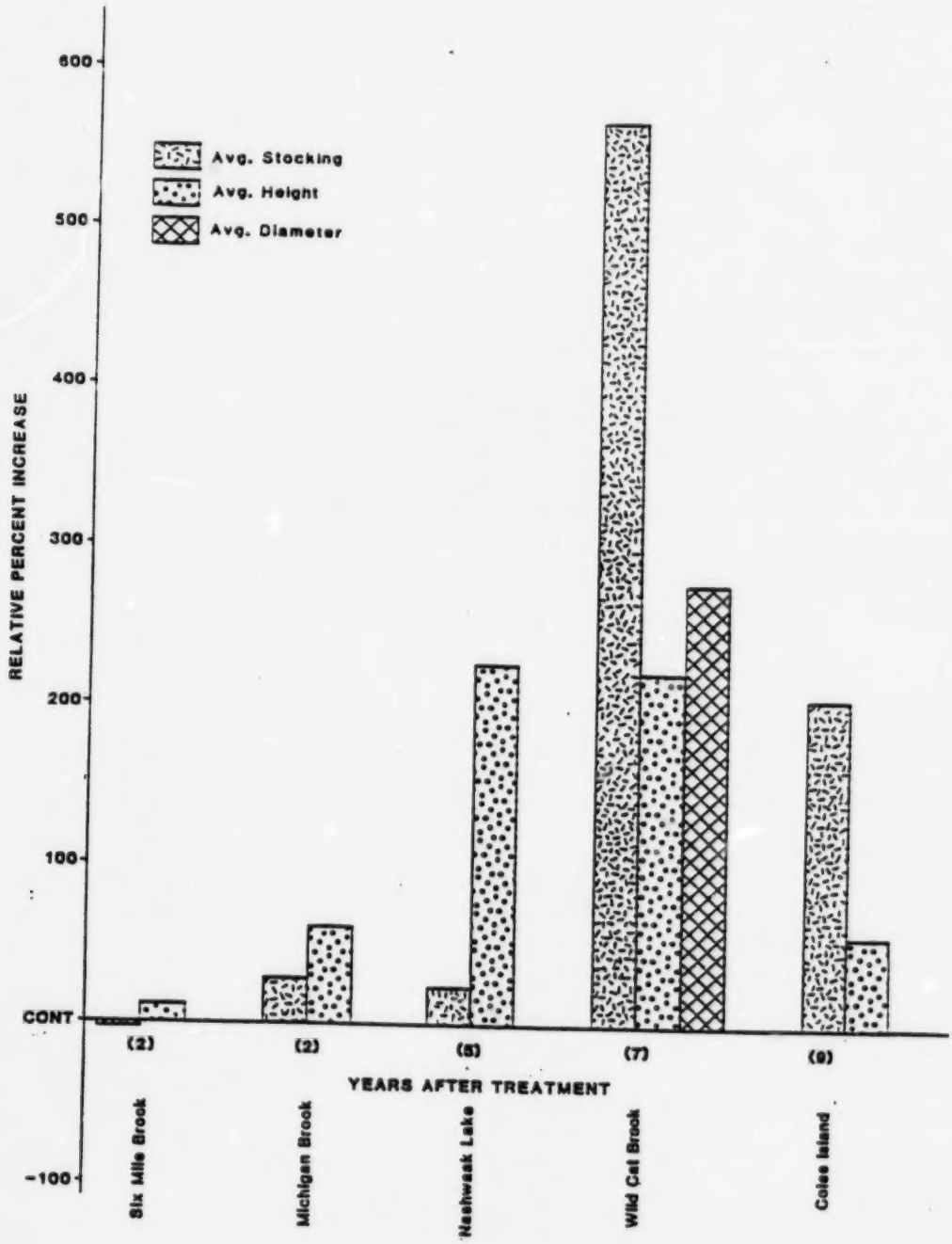
Location	Yr. Planted	Species	Yr. Sprayed	Growth Response Period (Yrs.)	STOCKING NO. TREES/HA		AVERAGE HEIGHT M		AVERAGE DIAMETER cm	
					Control	Treated	Control	Treated	Control	Treated
Six Mile Brook	1984	bs	1985	2	2 200	2 100	0.415	0.465		
Michigan Brook	1984	jp	1985	2	1 450	1 850	0.581	0.912		
Nashwaak Lake	1981	bs	1982	5	2 100	2 600	0.524	1.714		
Wildcat Brook	1976	bs	1980	7	300	2 000	0.762	2.428	1.294 (*0.006	4.875 0.288)
Coles' Island	1976	jp	1978	9	1 050	3 200	3.160	4.934		

* Volume index is expressed in m^3/ha.

$V = D^2H$

where V = volume index
D = diameter 6" above ground
H = total tree height

FIGURE I. Relative growth response to herbicide treatment (CONTROL = 0%)



ESTIMATING OFF-TARGET GROUND DEPOSITION OF HELICOPTER APPLIED GLYPHOSATE SPRAYS IN FORESTRY

C. M. RILEY AND C. J. WEISNER

Current permit guidelines from the New Brunswick Department of Municipal Affairs and Environment demand that a 65 m no-spray buffer zone must be observed around watercourses when applying silvicultural herbicides by helicopter. This figure of 65 m is based on a swath width of an agricultural fixed-wing aircraft spraying insecticide rather than upon application - specific experimental results. Recent work by Payne et al. (1986) suggests that for some application systems, a 25 m buffer zone would be adequate; however the systems tested did not include those currently used in New Brunswick.

The main objectives of this study were: i) to assess off-target ground deposition of glyphosate up to a maximum 200 m downwind of blocks sprayed by helicopter under typical New Brunswick operating conditions, ii) to determine the effectiveness of the existing 65 m water course buffer zone and assess the potential for its reduction.

Three results of this study, in particular, require further consideration, namely; (i) the deposition of relatively large droplets at distances greater than 100 m from the edge of the target area, ii) the relatively low deposits observed within the target area, and (iii) the relatively gradual decrease in off-target deposit with distance which was observed when compared to the study by Payne et al.

In order to explain these results, it is necessary to consider the aerodynamics of rotary wing aircraft and behavior of the aircraft vortices or wake. The lift generated by a rotary wing aircraft, unlike a fixed wing aircraft, is not uniform across the wing span but is concentrated in a region corresponding to 70-90% fo the rotor diameter. Since more lift is induced in this region, the strength and total amount of circulation or vorticity created is also greatest in this region. In order to avoid excessive entrainment of spray droplets within the helicopter wake, atomizers should not be located within or beyond the distance corresponding to the region of maximum lift generation.

The Bell 206 B used in this study had a boom length of 13.1 m which clearly extended beyond the 9.9 m diameter rotor blade. It is highly probable, therefore, that spray emitted from at least several metres of boom was released almost directly into wing-tip vortices and the aircraft wake. Once entrained, the behavior of the spray, rather than being influenced by gravity and meteorology alone, would also be heavily influenced by the

lateral and vertical forces operating within, and for the lifetime of, the aircraft wake. This may explain the deposition of relatively large droplets beyond 100 m as well as the apparently poor swath distribution pattern and the gradual decrease in off-target deposition. The 8.5 m boom used in the study by Payne et al. was only 75% of the aircraft rotor diameter. Unfortunately, no indication of deposited droplet size were given. Poor spray distribution results from increased boom length were also seen by Winterfeld and Moffitt (1981).

As the forward speed of rotary winged aircraft increases, the size of the two wing-tip vortices becomes unequal and an asymmetry is introduced into the shape of the aircraft wake. At higher airspeeds, this asymmetry can produce a poor swath distribution pattern with a symmetrical nozzle layout (Parkin, 1979). Nozzles spaced equally along the boom in the RPC study coupled with the 36 m s^{-1} airspeed could have contributed to the low deposits observed within the target area.

Longitudinal boom positioning relative to the position of the rotor wake is also an important consideration in terms of spray distribution and dispersal. Droplets, once emitted from the spray nozzle, quickly lose any velocity imported to them during atomization and fall under gravity into still air. Unless the droplets are very large (> 400 m diameter) (Quantick, 1985) they remain airborne prior to being influenced by the rotor wake. Obviously, the more forward the location of the boom and the slower the airspeed, the greater the time droplets have to sediment (and possibly even deposit) between droplet emission and potential contact and influence by the rotor wake. In the present study, airspeeds were relatively high (36 m s^{-1}) and the boom was located directly beneath the rotor shaft.

The study of Payne et al "was designed to measure off-target deposit resulting from the small drop size range and to estimate buffers...from this type of drift". Spray applications were made under meteorological conditions considered to represent a worst case condition for small droplet drift, i.e. stable atmospheric conditions, 88% relative humidity, mean wind speed < 0.6 m/s and full cloud cover. When determining off-target deposition for he purposes of establishing no-spray buffer zones, worst case conditions to produce maximum deposits in the non-target area should be sought. Large off-target deposits in the near field (i.e. typical buffer zone range) are more likely to be achieved by gross swath displacements under high wind speed conditions than by deposition of small "drift prone" droplets under low wind speed conditions. Although the latter scenario is suitable for long range off-target deposition and drift studies, studies performed under high wind speeds might yield more meaningful "worst case" results for determining short-range buffer zones

from aquatic environments. This is particularly the case where only a small volume fraction is emitted as "small droplets" as in the case of aerially applied herbicide sprays in forestry.

Calculating from the regression line equations developed from the data provided by this study, the current 65 m buffer zone for an application rate of 1.7 g ai/ha would give rise to at best, deposits which were equivalent to 63 g ai/ha and at worst, equivalent to 96 g ai/ha. The biological significance of these results as they relate to buffer zones is being assessed.

REGULATORY ACTIVITIES

OPERATIONAL FOREST SPRAY MONITORING

W. A. SEXSMITH

ABSTRACT

The New Brunswick Department of Municipal Affairs and Environment has the mandate to regulate pesticide application in the Province, including both the spruce budworm spray program and the forest herbicide spray program. The total number of man hours spent monitoring these programs for permit compliance was 234 and 139 respectively, with 6 and 9 incidents respectively (complaints, etc.) investigated. Four spills or jettisoned loads occurred, all relating to the spruce budworm program (Table 1). No significant environmental impact was reported.

All municipal drinking water supplies situated in watersheds that had insecticide spray activity were sampled before and after (for aminocarb and fenitrothion only) applications took place. As in previous years, no evidence of pesticide residues (detection limits: aminocarb 0.1 ppb, fenitrothion 0.01 ppb) in these water supplies was found in 1987. No such sampling was done for the herbicide program.

Setbacks or buffer zones, have been used as a regulatory tool over the years in New Brunswick as a means to protect designated sensitive areas from impact of spray operations. Setbacks that were in place for 1987 for the forest insecticide spray program are indicated in Table 2 and for the forest herbicide spray program, Table 3.

Setbacks for research applications, not indicated in the tables, were 8 km from human habitation for a new (unregistered) active ingredient, and 3.2 km from human habitation for a previously registered active ingredient.

These buffer zones, although there have been few changes in the past few years, are not meant to be static but are such that they may change as the information available changes.

Table 1. Pesticide spills/jettisoned loads in operational forestry programs in 1987.

Date	Agency	Product	Amount	Location	Cause
June 6	Forest Protection Ltd.	Fenitro-thion	200 U.S. gal	Boston Brook	TBM crash
June 10	Forest Protection Ltd.	Fenitro-thion	625 U.S. gal	Boston Brook	TBM dump door tripped
June 16	Forest Protection Ltd.	Dipel 132 B.t.	112 U.S. gal	Coal Branch	engine problems
Aug. 11	J.D. Irving Ltd.	Fenitro-tion/amin-ocarb	10 U.S. gal	Boston Brook	residual insecticide in hose

Table 2. Setbacks for the 1987 Spruce Budworm Spray Program in New Brunswick

	Woodlands*	Woodlots**	
	H_2O***	H_2O	B.t.
Habitation	1.6 km	300 m	155 m
Lakes (> 40 ha)	400 m		
Designated major Rivers	400 m		
Open water bodies		65 m	0
Ecological reserves	400 m	65 m	65 m
Municipal water (point of extraction)	3.2 km	3.2 km	3.2 km
Blueberry fields	3.2 km	3.2 km	0

* TBM aircraft
** Agricultural type aircraft
*** Water-based chemical formulation

Table 3. Setbacks for the 1987 Forest Herbicide Spray Program in New Brunswick

Habitation	155 m
Open water bodies	65 m
Municipal water (point of extraction)	3.2 km

MONITORING IN OTHER JURISDICTIONS

ENVIRONMENTAL MONITORING CARRIED OUT FOR THE AERIAL SPRAYING OF BIOLOGICAL INSECTICIDES AGAINST THE SPRUCE BUDWORM IN QUEBEC IN 1987

by

P.-M. MAROTTE, J. CABANA AND R. DOSTIE

In 1987, the ministère de l'Energie et des Ressources (MER), using single and four-engine planes, sprayed 197,992 ha with Dipel 132* (B.t.) in order to combat the spruce budworm. As in previous years, the MER established a program of environmental monitoring and follow-up to be carried out in conjunction with the spraying program so as to determine the concentrations of insecticides in various environments both inside and outside treated areas. The studies carried out in 1987 were mainly focused on the persistence of insecticides after spraying and the environmental follow-up. Samples were taken from lotic and lentic environments, sediments, forest soils, drinking-water outlets and a fish hatchery. As well, a study was done to determine possible contamination of the air in municipalities situated near the areas treated. The MER's microbiology laboratory carried out a total of 834 analyses in connection with these projects. Visual monitoring of operations was carried out during more than 15% of the applications.

Environmental Monitoring and Follow-up

A first group of projects was related to the persistence of viable B.t. spores in the environment. The persistence of spores was evident a year after spraying. We are thus planning to complete the persistence study at the end of next year (permanent stations).

Of the 82 stations sampled in 1987, 20 streams, 14 lakes and 27 soil stations were located inside the areas treated in 1985, whereas 9 rivers, 6 lakes and 6 soil stations were located outside these areas. It should be noted that a considerable area of the river's watershed was treated. A total of 184 samples were collected for the study.

*A single plot was experimentally treated with Dipel 176 (927 ha).

After two years, preliminary analyses indicate that concentrations have decreased approximately tenfold in most of the lakes situated inside the areas treated in comparison with the 1986 results. The concentrations found this year were lower than 0.112×10^4 C.F.U./l. In streams treated in 1985, and in the rivers situated outside spray blocks, concentrations were lower after two years than after the first year, but the decrease was less marked than that observed in lakes. Concentrations in the organic sections of forest soils are those which decreased the least: some of them were almost equal to those observed after the first 11 months (from 1.2×10^4 to 29 x 10 C.F.O./g).

As part of the 1987 program of environmental follow-up, 58 stations were established in order to monitor the evolution of B.t. in different substrates (air, water, sediments and forest soil). A total of 594 samples were taken.

In 1986, significant concentrations of B.t. spores were observed in the sediments of two lakes. These concentrations were equal to those found in the forest soil immediately after spraying. In view of these facts, sediment samples from thirteen lakes were taken in 1987. Five of these lakes had been treated with B.t. over a three-year period, while the remaining eight lakes were situated in areas that had never been sprayed with B.t..

Three drinking-water outlets and a provincial fish hatchery were monitored throughout the duration of operations. Given that an oil-based B.t. was used this year, samples of forest soil were taken to be compared with those of previous years, when a water-based B.t. was used. It should also be noted that air samples were taken in four municipalities in order to determine the drift of B.t. spores and estimate the concentrations to which people might be exposed. Initial analyses reveal either an absence of spores or their presence in extremely small quantities (from non-detectable to 59.5 C.F.U./m^3.

It should be noted that there were no leaks or spills of the product in 1987.

ENVIRONMENTAL MONITORING OF HERBICIDE SPRAYING CARRIED OUT IN QUEBEC IN 1987

L. LABERGE, AND P.-H. MAROTTE

MONITORING

In 1987, almost 12,000 ha of forest were treated, or slightly more than twice the area treated in 1986. Most activities involve clearing away competitive species of vegetation from planted areas, or preparing the ground for reforestation. Chemical clearing operations are generally carried out between early August and mid-September, while ground preparation prior to planting takes place mainly in May and June.

Environmental follow-up consisted largely in the analysis of residues observed in areas which had been sprayed from the air with glyphosate, and in areas which had been treated with hexazinone applied from the ground with spray guns. This type of environmental follow-up was necessary given that the MER was using these particular combinations of methods and products for the first time.

In 1987, samples of water, soil, sediments and air were taken. The biological components studied were vegetation (leaves, fruit, branches) and man. As well, artifical substrates were used to determine the extent and distribution of the deposit during aerial sprayings.

Apart from the environmental follow-up, particular attention was paid over the years to the possible exposure of workers to the chemical. A three-year contract ending in 1988 was granted toxicologists working at the Université Laval hospital centre. Almost 450 urine samples were collected for this study.

Almost 200 samples were required to evaluate glyphosate residues in the environment, while the study of drift and deposit demanded 325 samples. Approximately 140 samples, taken mainly in the physical environment, were used in the study of hexazinone. All the above-mentioned analyses were carried out by the MER laboratory which had to develop new techniques of analysis for this purpose.

No study of residues in fauna has yet been undertaken by the MER. However, studies on game animals exposed to glyphosate are being planned for 1988.

1987 HEMLOCK LOOPER CONTROL MONITORING PROGRAM IN NEWFOUNDLAND

R. Martin

The Department of Forest Resources and Lands (DFRL) was involved in spraying approximately 78 blocks (approximately 170,000 ha) on the west coast of Newfoundland in response to outbreaks of the eastern hemlock looper (Lambdina fiscellaria fiscellaria). Of the blocks treated, 62 received two treatments of the chemical insecticide fenitrothion (Folithion^{R}), eight received one application, while two received a partial second application. The biological insecticide B.t. was applied to 6 blocks with one of these receiving a second application.

Fenitrothion, an organophosphate insecticide, is a cholinesterase (ChE) inhibitor. ChE inhibition in birds probably causes death by blocking neurotransmissions in the respiratory centre of the brain or at myoneural junctions of respiratory muscles. There is considerable debate over the biological consequences of ChE inhibition. Regardless, ChE measurements in birds provide a means to measure animal exposure after applications of organophosphate insecticides. To monitor this exposure DFRL was directed to undertake a monitoring study on the impact of the 1987 hemlock looper control spray on forest songbirds as one of the stipulations for their operator's licence.

The monitoring sites consisted of 6 spray blocks located between Stephenville and Gros Morne National Park on the west coast of Newfoundland. As with the 1986 program, the objective of this study was to monitor the effects on forest songbirds of the DFRL spray program. There were two components to the study: a songbird study to monitor the effects of the spray on forest songbird populations and a foliage deposition study aimed at determining the amount of fenitrothion reaching the target forest vegetation.

The songbird study sampled specimens of upper canopy foraging blackpool warblers (Dendroica striata), mid-canopy foraging yellow-rumped warblers (Dendroica coronata) and ground-foraging white-throated sparrows (Zonotrichia albicollis). Following applications of fenitrothion at a rate of 210 g a.i./ha samples of each of the three groups were collected using a 410 gauge shotgun. Songbird brains were removed and stored in liquid nitrogen for later analysis of ChE activity.

The upper and mid-canopy foraging warbler species showed a greater ChE depression after the spray than did the ground-foraging sparrow. In general songbird brain ChE inhibition was evident several hours after the spray and further depressed one day later. Approximately 50% of all songbirds collected after spraying showed evidence of exposure to fenitrothion (based on

lower of the two values, either $\bar{x}$ - 0.2 $\bar{x}$ or $\bar{x}$ - 2 standard deviations). Approximately 17% of all the songbirds collected after spraying exhibited $\geq$ 50% ChE inhibition.

The fenitrothion deposition study using balsam fir foliage was conducted to show that songbirds had been exposed to a ChE inhibiting agent. There was large variation in samples in any particular spray block and large variation between spray blocks. The spray blocks that had received the highest levels of fenitrothion did not yield songbirds with the highest ChE depression.

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